

A plastic prototyping technology for microfluidics

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Keywords: PMMA, microfluidic chip, powder blasting, rapid prototyping

Introduction:

Developments in MicroElectroMechanical Systems (MEMS) technology have led to strong miniaturization of biochemical analysis systems and the lab-on-a-chip concept. While an important part of MEMS is based on silicon and fabrication techniques like used in microelectronics [1], the need for low-cost and disposable materials explain why plastic MEMS devices are particularly attractive [2]. We have developed a fast prototyping technology for microfluidics based on PMMA (polymethylmetacrylate) plastic sheets. The entire process is realised in an economic way out of the clean-room.

Fabrication technology:

The simplest fluidic chip realised with our method is composed of three PMMA layers stacked on top of each other: A bottom plate, a channel layer and a top layer. It can be extended to more complex fluidic circuits where more layers are necessary.

1st step: Micromachining and powder blasting. Channels and other planar structures are realised by powder blasting, a fast prototyping method. The PMMA sheet (250 micrometer thick in our application) is protected with a steel mask during the exposure to accelerated alumina (Al_2O_3) particles. The steel masks are cut with a Nd-YAG Laser. Meso-scale channels (500 micrometer wide, see Figure 1) have been routinely realised and assembled; the smallest obtained dimension is 100 micrometer for the channel width (Figure 2).

More complex structures, such as valve elements, for example, are machined with conventional precision milling tools.

2nd step: Layers assembly. A solution is spread on the surfaces for binding. Afterwards, the different layers are stacked, the alignment being ensured by guiding pins.

The bonding is achieved in a hot press at 70°C under the application of a small mechanical pressure. This assembly process only takes 5 minutes for each layer stack.

Practical application:

We have designed a chip having two integrated check-valves (Figure 3). The fluidic chip is composed of 8 layers of PMMA, 2 plates are precision milled (Figure 4). The check-valve membrane is obtained from a commercially available component. It constitutes of a silicone membrane that is tightened between two structured PMMA plates. The integrated valves are tested and compared to commercial one. As shown on Figure 5, the results are very similar. In a further test, fluorescein was injected at 1 bar and no leakage was observed (Figure 6). This pressure is much higher than the applied pressure in practical applications.

Conclusion:

We have developed a technology that is well suited for the fast prototyping of three-dimensional microfluidic chips, and especially for devices where multiple microfluidic functions are combined in a limited volume. The steps from the CAD design to the final assembly are rapid and simple, enabling the realisation of prototypes in a matter of hours. And last but not least: the method is cost effective and doesn't require an important investment.

References:

- [1] Fundamentals of Microfabrication: The Science of Miniaturization, M.J. Madou, CRC Press, California: 2002
- [2] Polymer microfluidic devices, H. Becker, L.E. Locascio, Talanta 56 (2): 267-287, 2002

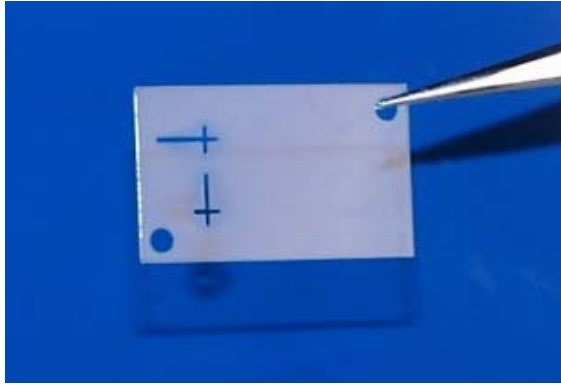


Figure 1 : Powder blasted PMMA layer (250 micrometer thick, 500 micrometer large channels).

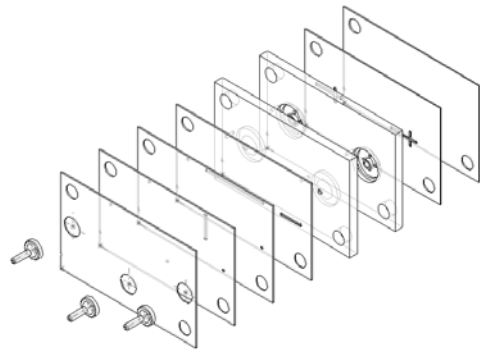


Figure 4 : Burst view of a microfluidic chip with integrated check-valves and external connectors.

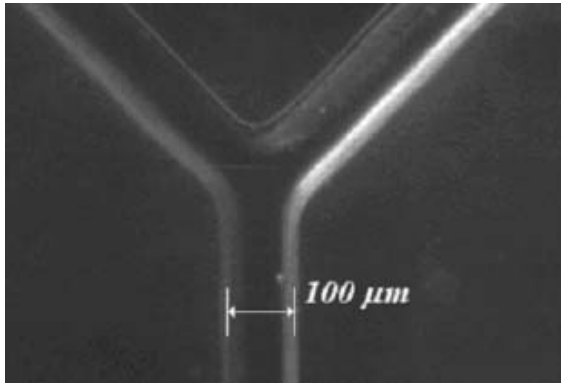


Figure 2 : photograph of a microfluidic chip having 100 micrometer large channels.

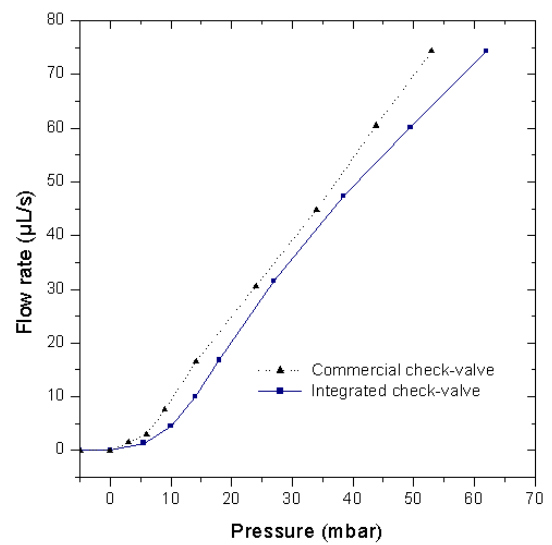


Figure 5 : Compared characteristics of the integrated check-valve with the commercial one.

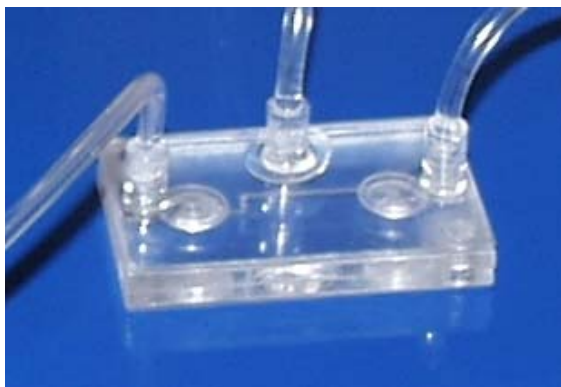


Figure 3 : PMMA microfluidic chip with 2 check-valves (dimensions: 36 x 22 x 5 mm, 8 layers).

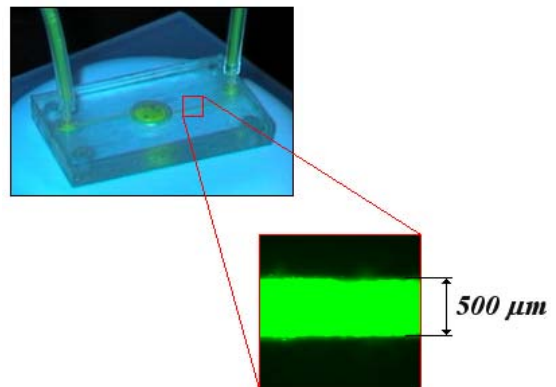


Figure 6 : Leakage test with fluorescein.